Diesel Injection: Breakup Mechanism

- Liquid turbulence creates surface perturbations
- Perturbations are stretched into ligaments due to relative velocity difference
- Ligaments break due to capillary forces and assisted by turbulence
- Broad range of drop sizes from primary breakup alone
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Gas Turbine Injector

- High-shear nozzle
  - inner injector consisting of 6 liquid fuel jets injecting into
  - swirling inner airflow
  - liquid jets atomize and may partly impact inner filming surface
  - film and atomized jets further breakup due to outer swirling airflow

Schematic of a high-shear nozzle illustrating the atomization process
Liquid Jet in Cross Flow Validation
Jet Penetration

- **Case 1:** $We = 40$, $q = 88$
- **Case 2:** $We = 155$, $q = 10$

\[
\Delta / D = 0.1 \quad I_h / D = 0.24
\]
\[
\Delta / D = 0.05 \quad I_h / D = 0.063
\]

☐: Experimental correlations: Wu et al. (1996), Sallam et al. (2004)
Liquid Jet in Cross Flow Validation

Liquid surface wave length

Time of onset of ligament formation

\[ \frac{\lambda_s}{D} \]

\[ \frac{t_i}{t_v} \]

\[ \mu_g \cdot \text{We}_g \]

experimental correlations (Sallam et al., 2004)
Liquid Jet in Cross Flow Validation

Deformation at onset of primary breakup

\[
\frac{d_J}{D} \quad \text{versus} \quad We_g
\]

Experimental correlations (Sallam et al., 2004)

\[We = 40 \quad q = 88\]

\[We = 155 \quad q = 10\]
Single Sector of High-shear Nozzle: No Swirl Case

- Operating conditions
  - air-inlet: 100 m/sec
  - liquid inlet: 18 m/sec
  - air density: 1.2 kg/m³
  - air viscosity: 1.8E-5 kg/m s
  - liquid density: 780 kg/m³
  - water viscosity: 1.5E-3 kg/m s
  - surface tension: 0.024 N/m
  - liquid injector diameter: 0.635 mm

  swirler vanes removed

- 2 meshes

<table>
<thead>
<tr>
<th>case</th>
<th>coarse grid</th>
<th>fine grid</th>
</tr>
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<tbody>
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<td>min grid size</td>
<td>D/16</td>
<td>D/32</td>
</tr>
<tr>
<td>mesh size</td>
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</tbody>
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Single Sector No Swirl Case Details

- Computational details of fine grid case

Cascade’s “adapt” tool used to locally refine grid in atomization region
30-degree Sector of High-shear Nozzle without Swirl
Velocity contours

\[ x_0 = +D \quad x_0 = 0 \quad x_0 = -D \]